Module 8

Problem Solving and Risk-Based Decision Making

October 1, 2009 **8:00 – 3:00**

NUCLEAR EXECUTIVE
LEADERSHIP TRAINING

Problem Solving and Decision Making

Robert Gossman
Senior Evaluator and Course Manager

Mr. Gossman is a Senior Evaluator and Course Manager for the Industry Leadership Development Department, Institute of Nuclear Power Operations (INPO). He was also Senior Evaluator at INPO, qualified in Chemistry and Human Performance.

Prior to joing INPO Mr. Gossman was a Chemistry Department Manager and System Test Engineer at Byron Nuclear Station. He holds a Senior Reactor Operator Certification on boiling water reactors. He was also a Chemistry and Physics instructor and a Coach at Winnebago High School, Winnebago, Illinois

Mr. Gossman holds a B.S. in Chemistry from Eastern Illinois University.

George Mortenson
Senior Program Manager

Mr. Mortenson is the Senior Program Manager, Industry & External Relations, Institute of Nuclear Power Operations. He is currently assigned as INPO liaison with the US Department of Energy and USNRC. Mr. Mortenson has primarily functioned as an operations, operational focus, and training/qualification evaluator during simulator and plant evaluations and accreditation visits. Mr. Mortenson is also qualified as an INPO Emergency Preparedness, Operating Experience, and Human Performance evaluator.

Mr. Mortenson holds a Senior Reactor Operator Certification on pressurized water reactors and has held a Senior Reactor Operator License on boiling water reactors. Before coming to INPO, Mr. Mortenson was a Shift Technical Advisor/Independent Safety Assessment Engineer at the Oyster Creek Nuclear Generating Station, and served as a Submarine Division Officer in the U.S. Navy.

Mr. Mortenson holds a B.S. in Physics/Mathematics from Creighton University.

INPO

Institute of Nuclear Power Operations

Managing Risk

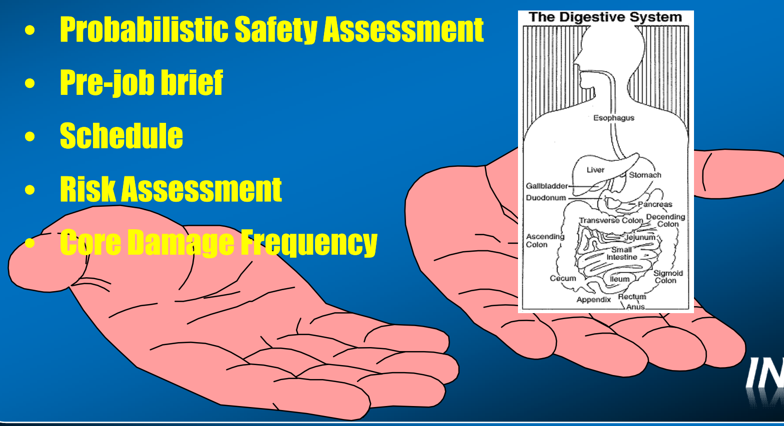
Bob Gossman and George Mortensen

The purpose of this session is to discuss and explore various aspects of risk management and operational decision-making.

INPO

Managing Risk: *Techniques*

- Probabilistic Safety Assessment
- Pre-job brief
- Schedule
- Risk Assessment
- Core Damage Frequency



INPO

Team Warm-up #1

How many pounds are in a short ton of coal?

A) 500 pounds
B) 1,000 pounds
C) 2,000 pounds
D) 2,400 pounds

Team Warm-up #2

The U.S. electric power industry, the dominant coal consumer, used how many million short tons of coal in 1997?

A) About 200 million
B) About 600 million
C) About 900 million
D) About 1,300 million

Team Warm-up #3

What percentage of the 1,128 million short tons of U. S. coal production in 2005 was used for electric power generation?

A) About 59 percent
B) About 81 percent
C) About 93 percent
D) About 99 percent

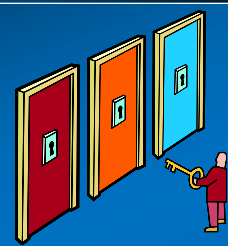
Managing Risk – Presidents Cup Racing

- (2) Teams
- Review the case individually and make race recommendation
- Discuss as a group, and make a TEAM decision
- Discuss/Critique

Aspects of Decision Making

- Determine the objective
- Determine available choices
- Manage distractions
- Determine the degree of conservatism required
- Apply knowledge to reduce uncertainties and develop contingencies

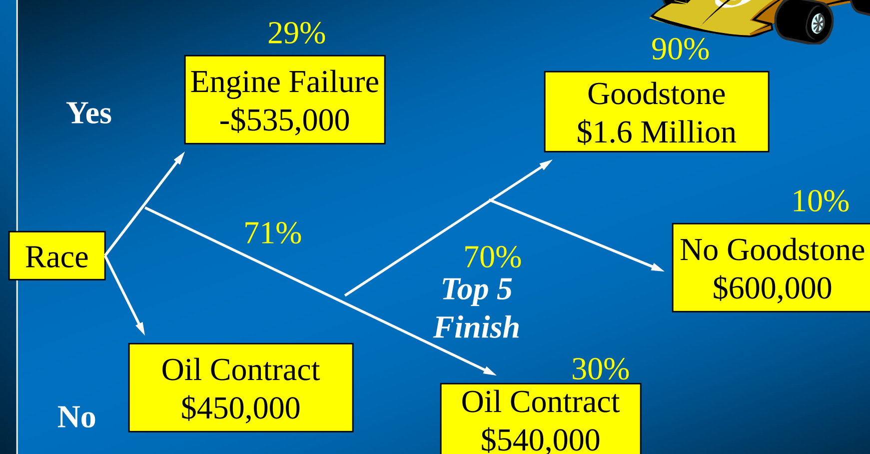
Testing Your Decision



Ask Yourself:

- What assumptions did we base this decision on?
- What's the worst thing that could happen if we proceed in this manner?
- Can I live with that? Can I defend the result?

Probabilistic Model



INPO

$$ER = .45(1.6\text{x}10^6) + .05(6\text{x}10^5) + .21(5.4\text{x}10^5) + .29(-5.35\text{x}10^5) =$$

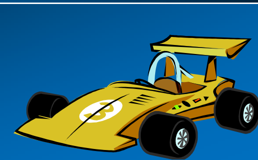
$$\$701{,}850$$

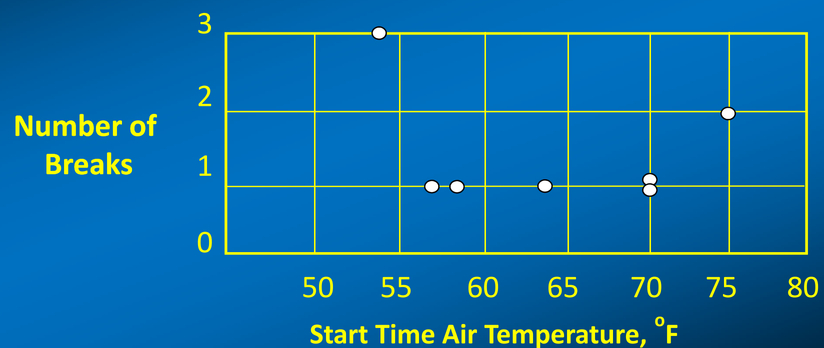
Versus

ER= $450,000 (Do not Race)

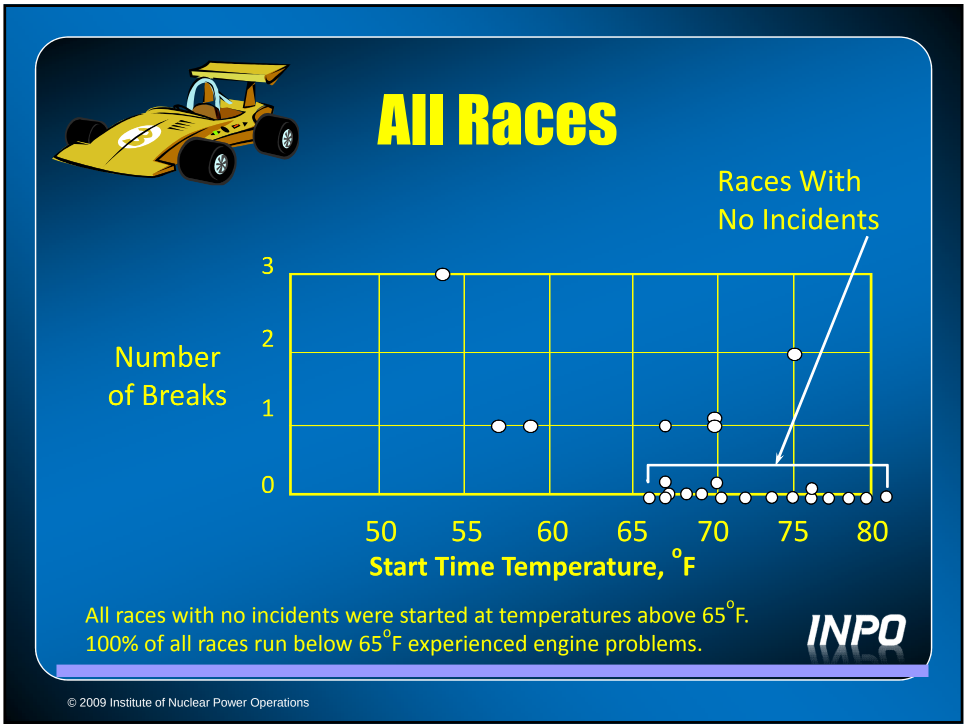
INPO

Races with Incidences of Gasket Failures





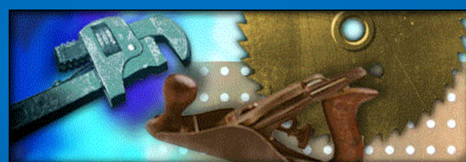
INPO


All Races
Races With
No Incidents
Number
of Breaks
3
2
1
0
50
55
60
65
70
75
80
Start Time Temperature, °F
All races with no incidents were started at temperatures above 65°F.
100% of all races run below 65°F experienced engine problems.
INPO
© 2009 Institute of Nuclear Power Operations


Warning Signs of a Crisis Atmosphere
1. Decisions must be made under pressure.
2. Fixed deadline must be met.
3. Wrong decision will have grave consequences.
4. Irregularities are present.
© 2009 Institute of Nuclear Power Operations

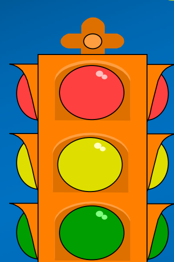
Risk Management - *Analytical Tools*

What kind of tools do you use to determine the degree of risk ?



INPO

Managing Risk – Warning Signs



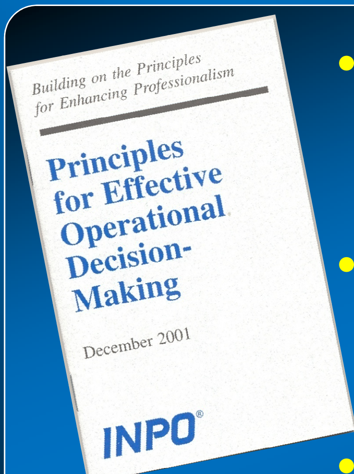
– STOP!
– Proceed with caution?
– OK to proceed

What are <u>your</u> personal warning signs ?

Risk Management - *Challenges*

- Late additions to work window scope
- Emergent work
- Schedule adherence problems
- Groups with unscheduled activities
  - (FIN, WIN etc.)..

INPO



- Developed by commercial nuclear industry
- Principles & Attributes that influence operational decisions
- Intended to be a tool to assist in operational decision-making

INPO

INPO

Institute of Nuclear Power Operations

RISK MANAGEMENT & RISK-INFORMED OPERATIONAL DECISION-MAKING (ODM)

George Mortensen & Bob Gossman
Institute of Nuclear Power Operations

The purpose of this session is to:

- Discuss the concepts of risk and risk management.
- Familiarize DOE personnel with the commercial nuclear industry's operational decision-making process.

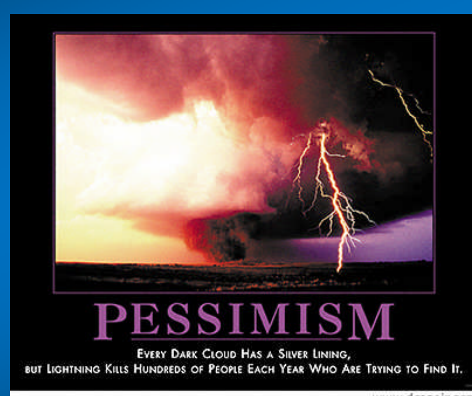
INPO

What is Risk?

- From Webster's Dictionary

  Risk *(noun)*

  "possibility of loss or injury, an insurance hazard from a specified cause or source"



Decision-making Quotes

"Wrong decisions made early can be recovered from. Right decisions made late cannot correct them."

Rule #82 – NASA Website

"Never make a decision from a cartoon. Look at the actual hardware or what real information is available such as layouts."

Rule #84 – NASA Website

INPO

Risk Quotes

"The Probabilistic Risk Assessment (PRA) is an underestimator of risk."

Anonymous

"We've always been successful in the past, it's time to bet on that success."

Anonymous Fac Rep

INPO

Decision-making Quotes

"Decades of research in decision-making has shown that humans are not rational decision-makers in any reasonable meaning of the term."

Erik Hollnagel

INPO

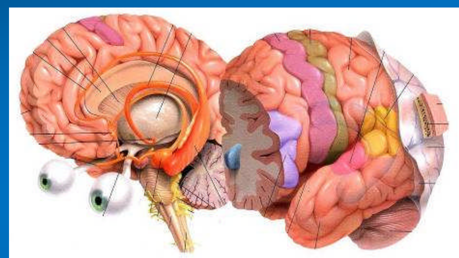
Risk Biology 101

- Serotonin levels and "**MAO**" (monoamine oxidase) levels in the brain may determine a "risk-taker" or "risk avoider"
- An extreme risk-taker will have 1/3 less MAO than "normal"
- Low MAO levels are also common in **athletes, performers, artists, and entrepreneurs** – and also criminals and those addicted to drugs
- The Human is the only animal that knowingly takes **"Risks" for pleasure**
- The decision-making pathways of **teenagers** are not well established.
- The adrenaline surge after a successful risk is a large **"PIC"** – Positive, Immediate, Certain effect

INPO

The Science of Fatigue

- The brain is a digital computer:
  - Electro-chemical
  - It cannot run continuously awake
  - It requires scheduled recharge & maintenance intervals
- **The brain accumulates "fatigue" when operating**
  - **It's computing at less than 100%**



- Fatigue is a physiologic state
  - *Not due to experience, motivation, or attitude*

INPO

Signs and Symptoms

Leadership

Decision Making

Adaptability; Flexibility

- Irritability, m… deterioration, … ce
- Impaired communicat…
- Reduced vigilance, inattention
- … for error and risk
- …plex reasoning & decision making
- Conservation of effort, r… …tiva…
- Forgetfulness
- … action
- …s"

Communication

Assertiveness

Mission Analysis

Situational Awareness

Threat & Error Management

INPO

Fatigue's Effects are Task-Dependent

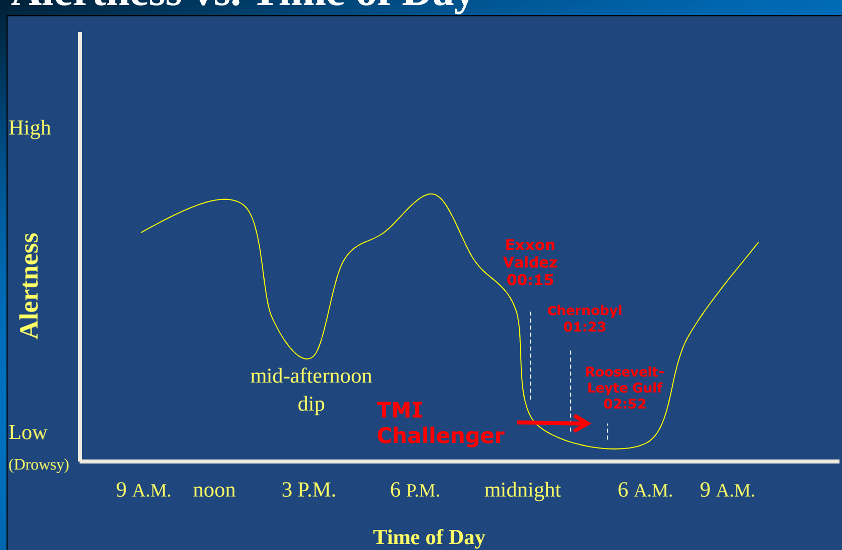
- Sense of well-being
- Judgment & decision making
- Vigilance & attention
-
-
-
- Well-learned/simple intellectual or physical tasks

ODM Process & Team training

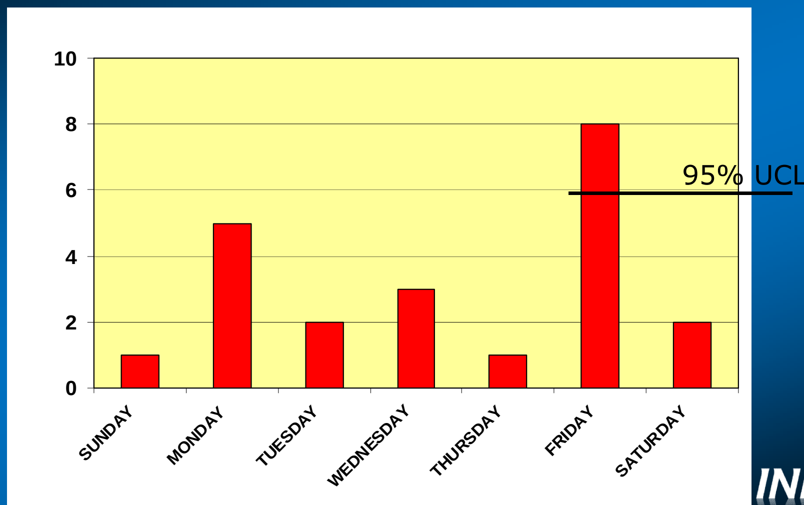
More resistant to Fatigue

INPO

Alertness vs. Time of Day



Fatigue Related Events -- by day of week (2000-2006) (Source: Navy Safety Center)



INPO

Risk Biology Conclusions

- Be careful when **teenagers** make decisions.
- Be more careful when **athletic teenagers** make decisions.
- Be even more careful when **athletic teenagers** make decisions on a **Friday**.
- Never let an **athletic teenager** make a decision at **3am** on a **Friday**!
- Seriously – Team skills (**inquiry**, **advocacy**, **leadership**, **conflict resolution**, and **feedback**) are needed when making critical decisions
  - Because of stress, haste, time, day of week, experience, personalities, and other factors

INPO

Commercial Nuclear Historical Perspective
Reactor Safety Study (WASH-1400) – 1975

Prior Beliefs	Major Findings in WASH-1400
Needed to protect against **large LOCAs** (Loss of Coolant Accidents)	Dominant contributors – **Small LOCAs** and **Transients**
Core Damage Frequency (CDF) is **low**	**CDF is higher** than expected (Best estimate: 5×10^{-5}, Upper bound 3×10^{-4} per reactor year)
Consequences of accidents would be **disastrous**	Consequences significantly **smaller**
Reactor "machine" was thought to be designed to be **"sailor-proof"**	**Support systems and operator actions very important**

INPO

Insights from EPRI Risk Models

- The degree of collaborative interaction between the operations and work management processes helps to limit plant risk.
- Operations and work management processes in either an insular (or highly competitive manner) results in detrimental risk impact.
- A "risk culture" has significant benefits in maintaining good performance and effectively controlling plant risk.
- Excessive intervention (either regulatory or management) at plants with effective risk management and good operational performance can be counterproductive to safety. (The reverse is also probably true)!

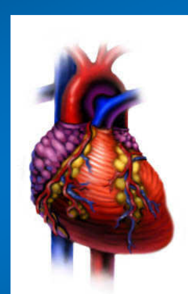
INPO

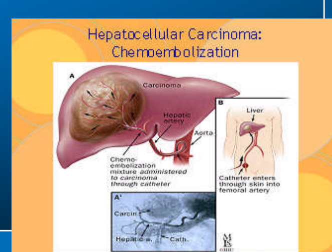
The Risks That We "Accept"

- *Annual Individual Occupational Risks*
  - All Industries: 7x10^{-5}
  - Coal Mining: 24x10^{-5}
  - Fire Fighting: 40x10^{-5}
  - Police: 32x10^{-5}
  - Airplane death: 4.3x10^{-8}
  - US President: 1,900x10^{-5}

Other Risks That We "Must Accept"

- *Annual Public Risks*
  - Motor Vehicles: 15x10^{-5}
  - All Cancers: 200x10^{-5}
  - Heart Disease: 271x10^{-5}
  - Total: 870x10^{-5}

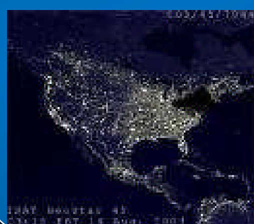




The Risks that are "Put onto" Us

Northeast Blackout (August 14, 2003)

- No major equipment failures



Plant	Complications	Normal CDF/Event Mean CDF	Time without power
Fermi-2	Gas turbine failed to start – recovered in 3 hours	5.0E-6 / 2E-4	6 hr. 19 min.
FitzPatrick	None	2.44E-6 / 9E-5	2 hr. 49 min.
Ginna	Primary relief valves opened once; Auxiliary feedwater failed to start	3.96E-5 / 2E-4	0 hr. 49 min.
Indian Point 2	None	2.6E-5 / 1E-4	1 hr. 37 min.
Indian Point 3	None	1.35E-5 / 7E-5	1 hr. 37 min.
Nine Mile Pt. 1	None	1.3E-5 / 3E-5	0 hr. 56 min.
Nine Mile Pt. 2	None	4.8E-5 / 5E-4	6 hr. 24 min.
Perry	Reactor core isolation cooling (RCIC) manually isolated at 3 hrs, 2 core cooling systems affected by keep fill system problem	7.4E-6 / 5E-4	1 hr. 27 min.

A Typical Commercial Nuclear Unit's Integrated Risk

Mode	Description	CDF	% of Total
1	Full-power (≥70% power)	4.28×10^{-5}	63%
2	Low-power (<70% power)	0.15×10^{-5}	2%
3	Hot Standby	0.08×10^{-5}	1%
4	Hot Shutdown	0.05×10^{-5}	1%
5	Cold Shutdown	0.91×10^{-5}	13%
6	Refueling	1.38×10^{-5}	20%
Total	Core Damage Frequency	6.86×10^{-5}	100%

Risk Levels on Commercial Nuclear Station's Safety Monitor

- See Handout #1

INPO

Historical Perspective

- Quantitative Safety Goals of the NRC
  - Early and latent cancer mortality risks to an individual living near the plant should not exceed 0.1% of the background accident or cancer mortality risk, approximately
    - **$5x10^{-7}$/reactor year for early death** (between plant site boundary and 1 mile beyond the boundary)

    and

    - **$2x10^{-6}$/reactor year for death from cancer** (between the plant site boundary and 10 miles beyond this boundary).

INPO

Reactor Oversight Process

Cornerstones of Safe Operation (Part 1)

- **Initiating Events** - operations and events at a nuclear plant that could lead to a possible accident, if plant safety systems did not intervene.
- **Mitigating Systems** - measures the function of safety systems designed to prevent an accident or reduce the consequences of a possible accident.
- **Barrier Integrity** - the fuel rods, the vessel, and the piping is continuously checked for leakage, while the ability of the containment to prevent leakage.
- **Emergency Preparedness** - measures the effectiveness of the plant staff in carrying out its emergency plans.

INPO

Reactor Oversight Process

Cornerstones of Safe Operation (Part 2)

- **Occupational Radiation Safety** - monitors the effectiveness of the plant's program to control and minimize doses.
- **Public Radiation Safety** - measures the procedures and systems designed to minimize radioactive releases from a nuclear plant during normal operations and to keep those releases within federal limits.
- **Physical Protection** - measures the effectiveness of the security and fitness-for-duty programs.

INPO

NRC Reactor Oversight Process

- See Handout #2

INPO

Reactor Oversight Process

In addition to the cornerstones, the reactor oversight program features three "cross-cutting" elements:

– **Human performance**

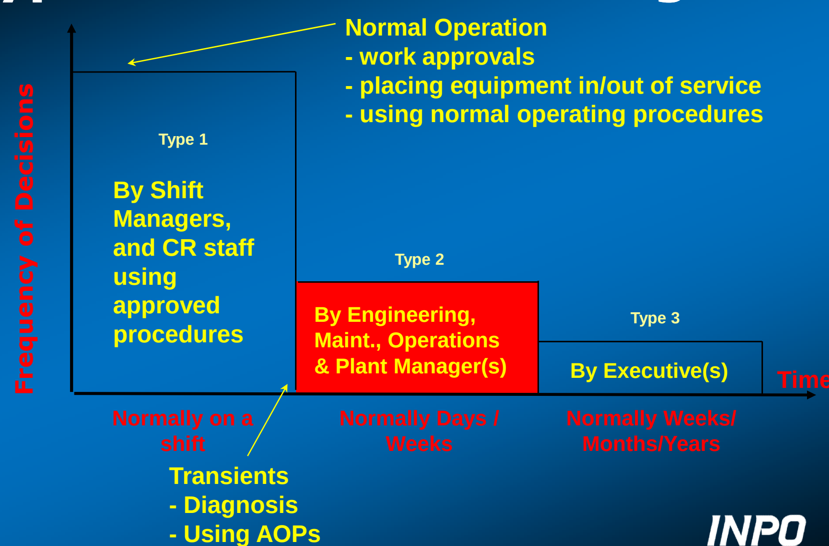
– **Management attention to safety and workers' ability to raise safety issues** (The so-called "safety-conscious work environment")

– **PI&R -- Finding and fixing problems** (The utility's corrective action program)

INPO

IDENTIFICATION OF AN OPERATIONAL DECISION-MAKING CONDITION

Types of Decision-Making



INPO

Example of Type 1 Decision: Station "X" Failure to Scram

- Failure of a valve during test.
- Manual scram test limit exceeded, but manual scram is not initiated.
- Automatic turbine trip setpoint exceeded, but manual scram not initiated.
- Station management was present in the control room.

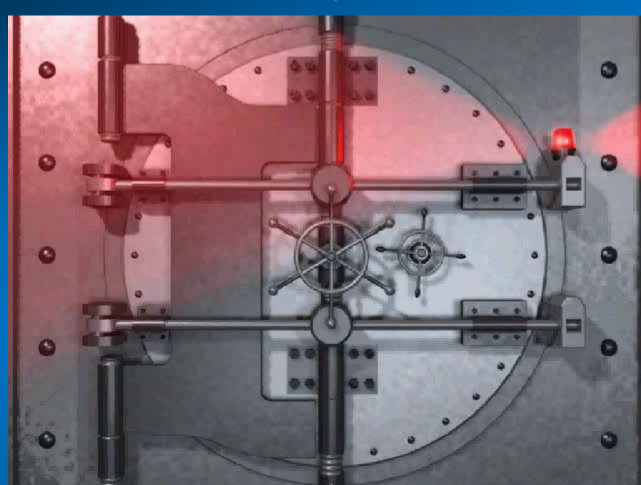
Example of Type 2 Decision: Station "Y" Reactivity Control Transient

- Reactivity control problems following startup
- Operations independently began troubleshooting the problem without engineering or management.
- A transient occurred during troubleshooting that reduced power – management approved power increase to 50% without determining cause.
- Hydrogen concentration significantly exceeded action levels – but management did not shut down the unit.

Example of Type 3 Decision: Utility "Z" Unit Construction

- One architectural engineering firm designed the unit for site "A."
- Due to labor problems, the plant was built at site "B."
- Site "B" – one existing unit (same design as the site "A" unit), but designed by a different architectural engineering firm.
- The utility did not modify the control room design of the new unit to address deficiencies (extra cost).
- Deficiencies contributed to a debilitating accident at the newer unit.

So.. Where does Operational Decision-Making Start?



Day-to-Day Examples?

- Severe weather (Nuclear plants)
- Loss-of-grid/grid instability (Nuclear plants)
- Submarine operations (USS Greeneville/USS San Francisco, etc.)
- Shuttle launch/landing (NASA)
- Chemical plant releases
- Security threat level decisions
- Airplane operations (FAA, etc.)
- Not just equipment problems
- In the DOE?

INPO

Welcome onboard today's flight to London, England

INPO

What are some popular Risk-related Decision-making Case Studies or Movies?

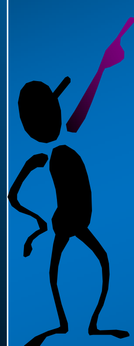
Case Studies/Events

- Road to Abilene
- Mount Everest
- Apollo 1
- Challenger event
- Columbia event
- Bhopal event
- BP Texas City

Movies

- The Andromeda Strain (1971)
- The Towering Inferno (1974)
- China Syndrome (1979)
- Apollo 13 (1995)
- Titanic (1997)

Principles for Effective Operational Decision-Making



Document Objective

- Provides a tool to support a culture in which managers systematically and carefully make sound operational decisions

INPO

Principles for Effective ODM

1. Conditions that potentially challenge safe and reliable operation are recognized and promptly reported for resolution
2. Roles and responsibilities are established for making and implementing decisions and are thoroughly understood by plant personnel

INPO

Principles for Effective ODM

3. Potential consequences of operational challenges are clearly defined and alternative solutions are rigorously evaluated
4. Decisions are based on a **full understanding of short-term and long-term risks** and the combined impact of conditions associated with various options

INPO

Principles for Effective ODM

5. Implementation plans are developed to effectively communicate actions, responsibilities, compensatory measures and back-up plans to ensure successful outcomes
6. Decisions and decision-making activities are periodically evaluated

INPO

Real-life Commercial Nuclear ODM Use Examples

- **Outage Rescheduled Because of Heavy System Load Demand**
- **Recirculation Pump Seal Failure**
- **Generator Hydrogen Leak**
- **Suppression Pool Crack/Leakage**
- **Circulating water system (Fish run) problems**
- **Others?**

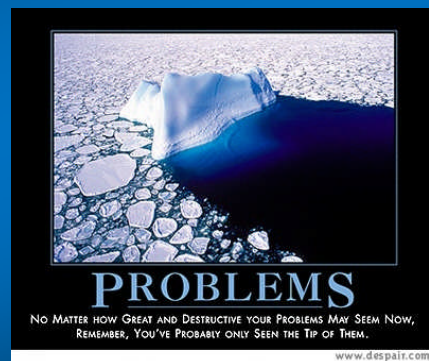
Typical INPO Plant Evaluation Areas for Improvement

Problems:

- Consequence Assessment and Contingency Planning
- Narrow ODM Scope
- Operational Impact and Contingency Planning

Causes:

- Management Tolerance
- Lack of Adequate ODM Process
- Expectations not Communicated
- Weak ODM Process



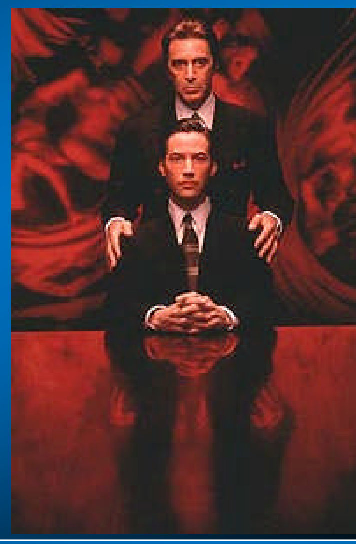
Warnings Flags Related to Decision-making

- Management focus on production values overwhelms messages related to safety and conservatism.
- Decision-making process is dominated by time and due dates.
- Employees are not involved, not listened to, and raising problems is not valued.

INPO

Commercial Nuclear Ideas

- Use of a random (or assigned) “Devil’s Advocate”
- Development of Decision-making Case Studies (when things go well, or when they could have gone better)



Commercial Nuclear Decision-making Tool

- See Handout #3

INPO

Commercial Plant Strength

- **Management has reduced plant risk by improving the quality of operational decisions. Trigger points for corrective actions, based on the potential for further equipment degradation, are determined and communicated. The Operational Decision-Making Issues (ODMI) program provides structure and guidance for effective operational decision-making.**
  - vibration on the Unit 1 low-pressure turbine shell
  - degraded cell on a Unit 2 safety-related battery

INPO

Commercial Nuclear Strength

- A consistent operational approach is used to monitor adverse conditions that are outside normal operating bands. Plans are developed that provide a **standard method** for monitoring, aligning organizational support, identifying contingency actions, and **identifying communication** requirements when equipment is at increased risk.
  - Plans are developed based on the potential for equipment degradation or reduced operating margins
  - Plans include a condition statement, enhanced monitoring, contingency actions, and criteria for termination.
  - A plan was developed for a unit main power transformer gassing condition.
  - Fuel defect plan provides consistent operational guidelines for implementing slower ramp rates for power changes.

INPO

Strength (Various)

- Use of an aggregate impact performance indicator to define when unacceptable equipment condition has unduly affected operations.
  - operator workarounds
  - operator burdens
  - nonoutage control room deficiencies
  - nonoutage clearances more than 90 days old
  - component deviations because of equipment deficiencies

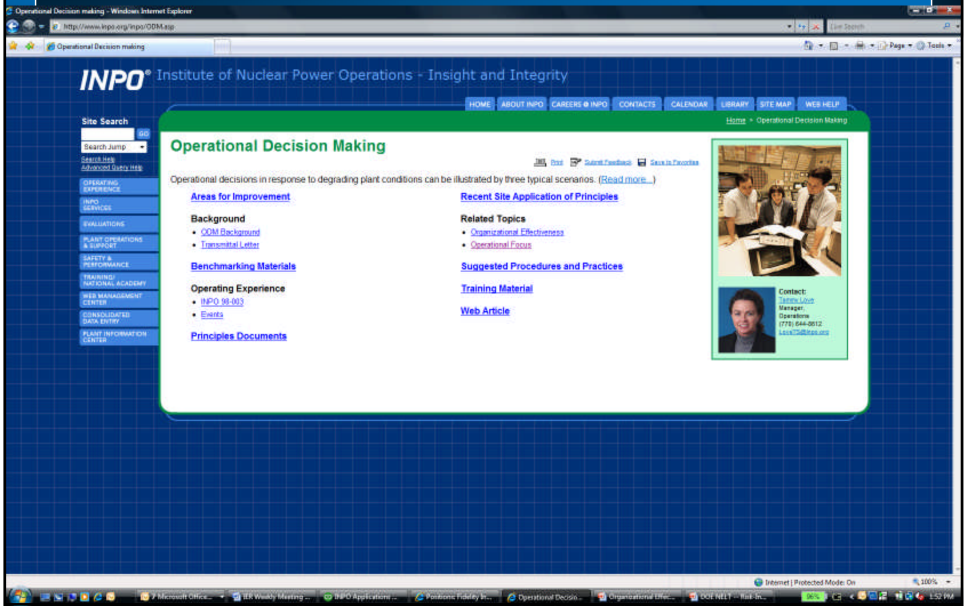
INPO

Safety and Operational Benefits of Risk-Informed Initiatives (see Handout #4)

- ***An EPRI White Paper --*** February 2008
  - Risk-informed activities have become ingrained in U.S. nuclear power plant operation over the past 15 years, providing both safety and operational benefits.
  - Risk-informed approaches have become a “win-win” for both the regulator and the licensees. The regulator can focus on issues truly important to safety, while licensees gain operational flexibility and an opportunity for cost reductions.

INPO

What's on the INPO Web site?

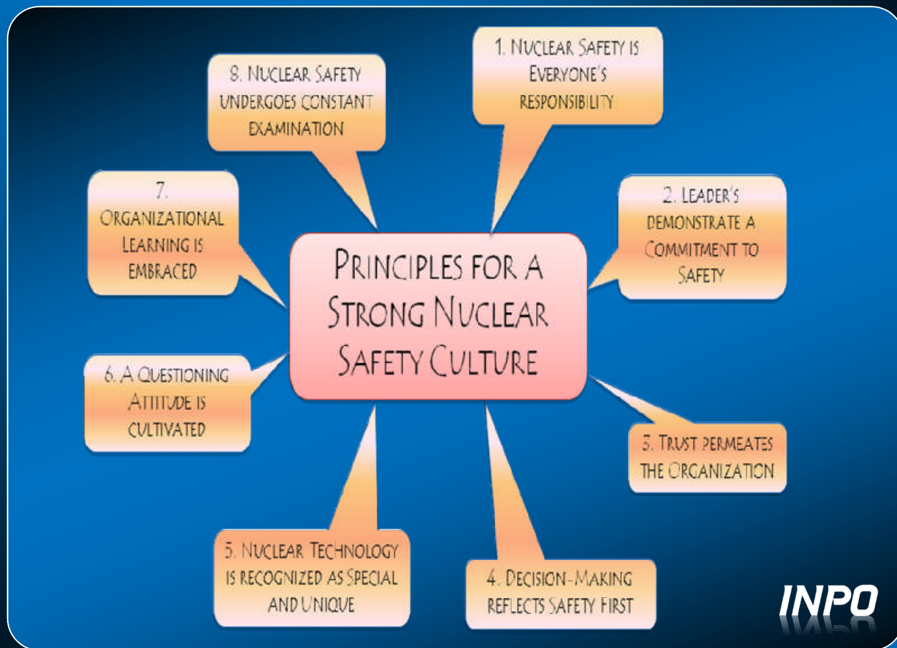


INPO

Institute of Nuclear Power Operations

One of those day-to-day examples

(A Case Study -- Based on an actual nuclear plant event)



So…..What did we learn?

- Risk Biology
- Types of decision-making situations
- 6 Principles of ODM
- Successes
- "The INPO Challenge"
  - Implement a process
  - Train people
  - Self-assess